Classification and Regulation of External Cardiac Compressors

21 CFR 870.5200

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Office of Device Evaluation
Food and Drug Administration

Circulatory System Devices Panel Meeting
September 11, 2013

Objective of This Panel Meeting

External Cardiac Compressors are currently Class III, but marketed through the 510(k) process

Do we have sufficient evidence of safety and effectiveness?
&
Are general controls sufficient and/or can special controls be established to mitigate the risks?

Yes → **Down-classify to Class I Or Class II**

No → **Remain as Class III**

FDA Team Presenters

Catherine Wentz, MS

Introduction, Regulatory history, risks to health,

FDA concluding remarks/recommendation

Xianghua (Henry) Yin, MD

Literature review

Outline

- Regulatory History
- Device Description(s)
- Cleared indications
- Reclassification Orders
- Risks to Health
- Evidence (including Literature review)
- Proposed Regulation

Regulatory History

- 1979 Proposed Rule for §870.5200
  - Class III
- 1980 Final Rule §870.5200
  - Class III
- 2009 515(i) Order for remaining Class III pre-amendment devices
- January 8, 2013 Proposed Order

1980 Final Rule

870.5200 External Cardiac Compressor

- *Identification*. An external cardiac compressor is an external device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest.
- *Classification*. **Class III (premarket approval)**

No effective date was established for the submission of premarket approval applications.

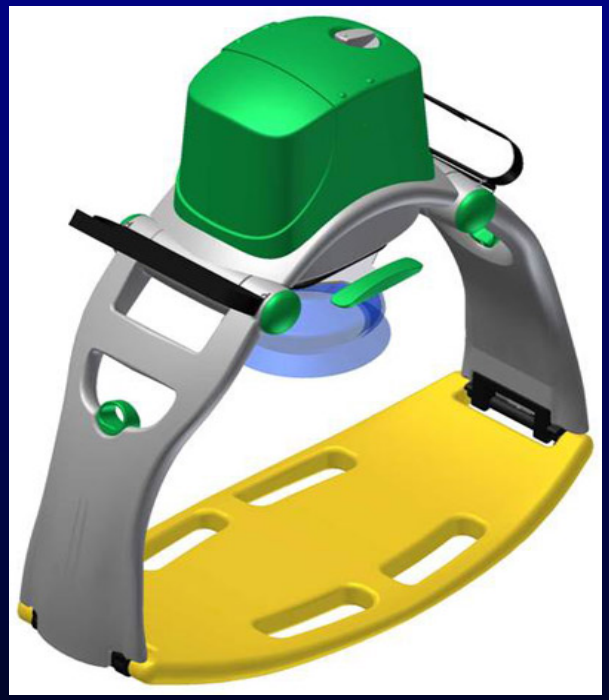
Devices Regulated

§870.5200 External Cardiac Compressor

- External Cardiac Compressors (DRM)
- Cardiopulmonary Resuscitation Aid Devices (LIX)

Device Description

- External Cardiac Compressor - Piston Designs



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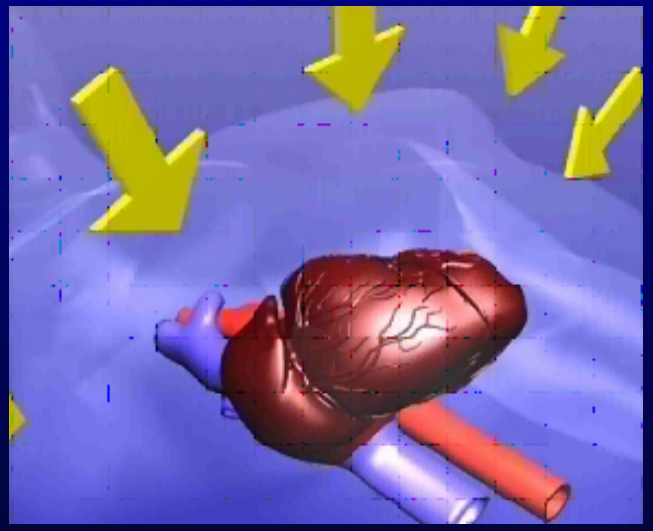
Device Description

- Band Design



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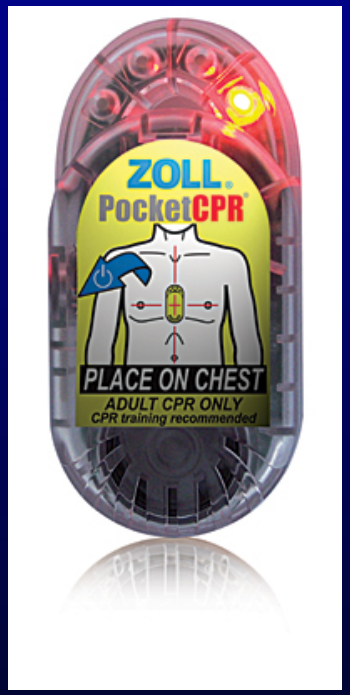
Device Description

- CPR Aid Devices



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Indications

External Cardiac Compressors

- 1979 Original Classification Panel
  - "…the device is not designed to replace manual CPR. The literature seems to recommend it for certain situations such as long-term applications and patient transport."
- Current Indications
  - ECC
  - CPR Aids

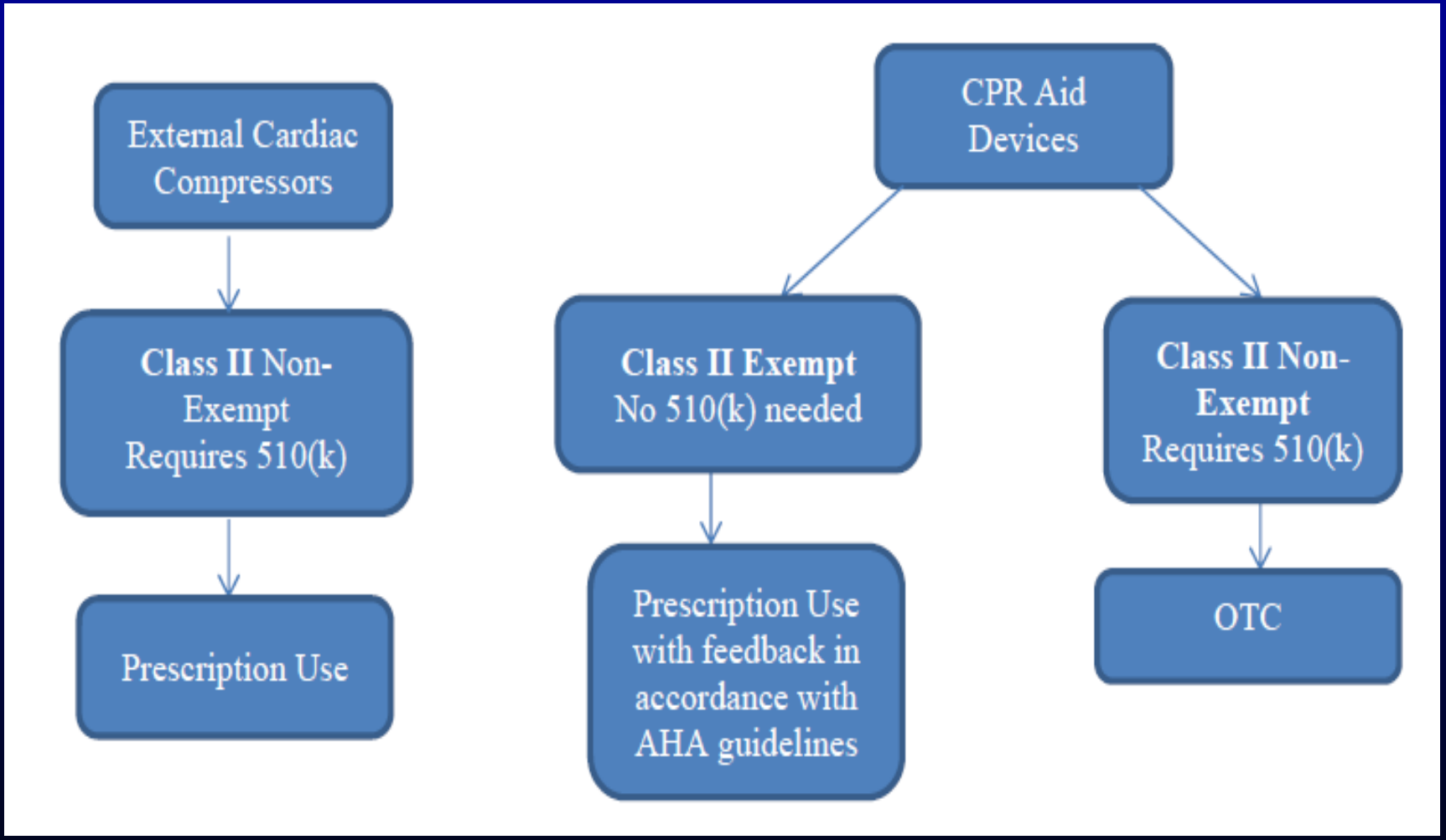
Regulatory History

- 1979 Proposed Rule
  - Class III
- 1980 Final Rule
  - Class III
- 2009 515(i) Order for remaining Class III pre-amendment devices
- January 8, 2013 Proposed Order

2009 515(i) Order and Industry Response

- 4 responses
- All in favor of reclassification
  - Ability to apply consistent CPR in accordance with current accepted guidelines
  - Risks are same as manual CPR

January 8, 2013 Proposed Order Downclassify from Class III to Class II

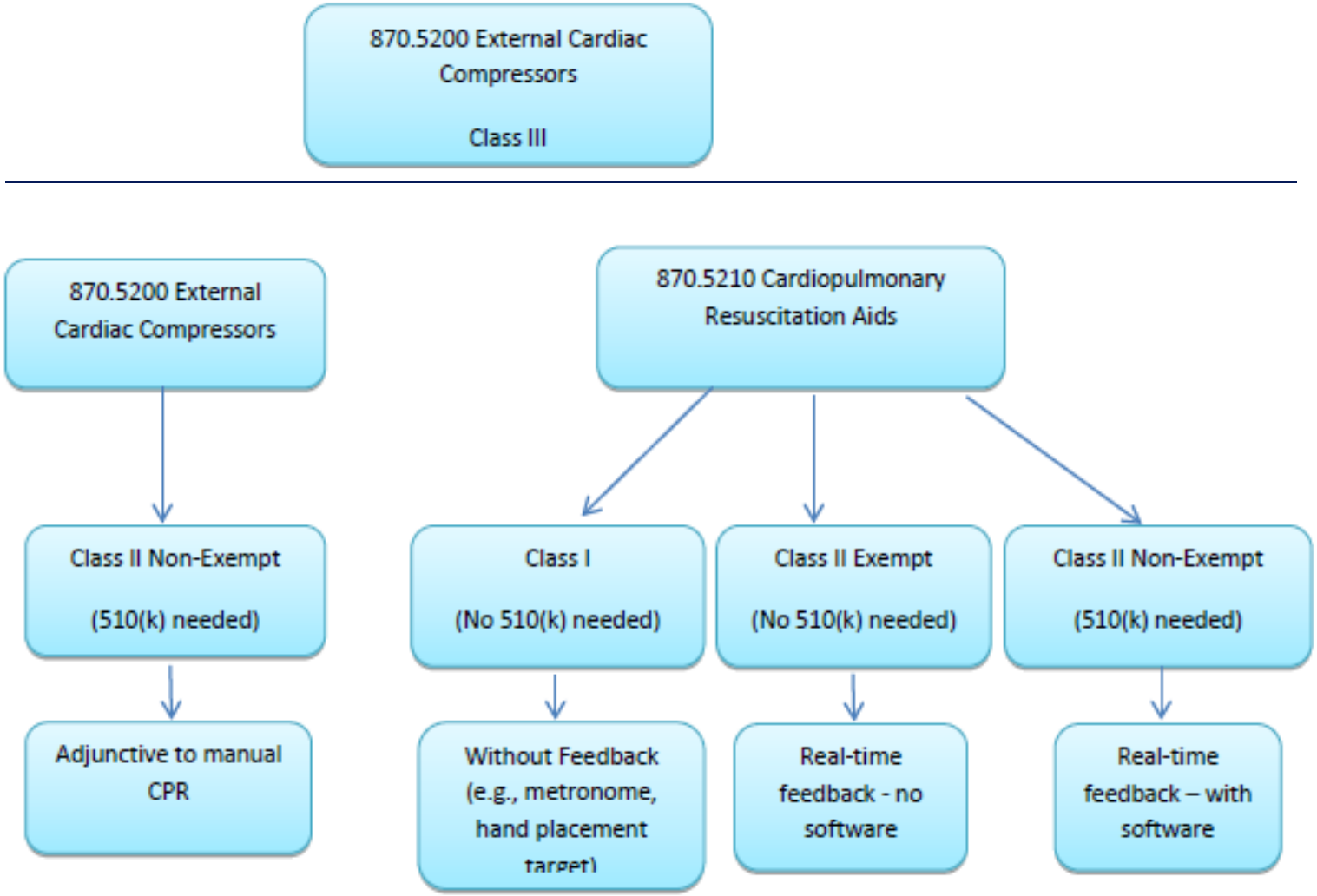


Comments to January 8, 2013 Proposed Order

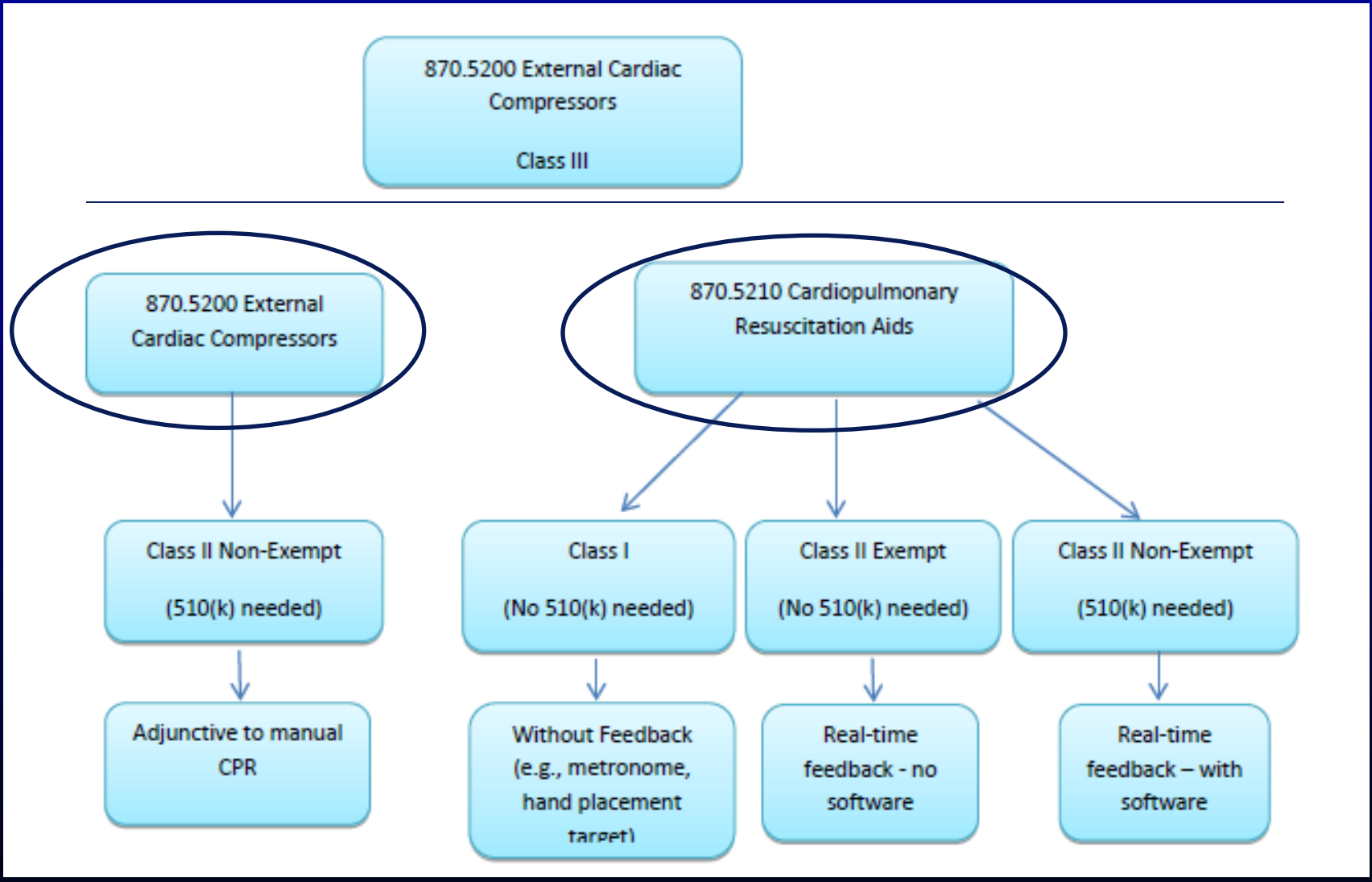
Comments were received from 4 sources:

- 2 of 4 agreed with FDA's proposed reclassification of 870.5200 External Cardiac Compressors and CPR Aid devices;
- 1 of 4 agreed, but had additional suggestions regarding the regulation of a subset of the CPR Aid devices; and
- 1 of 4 disagreed.

FDA Proposal



FDA Proposal



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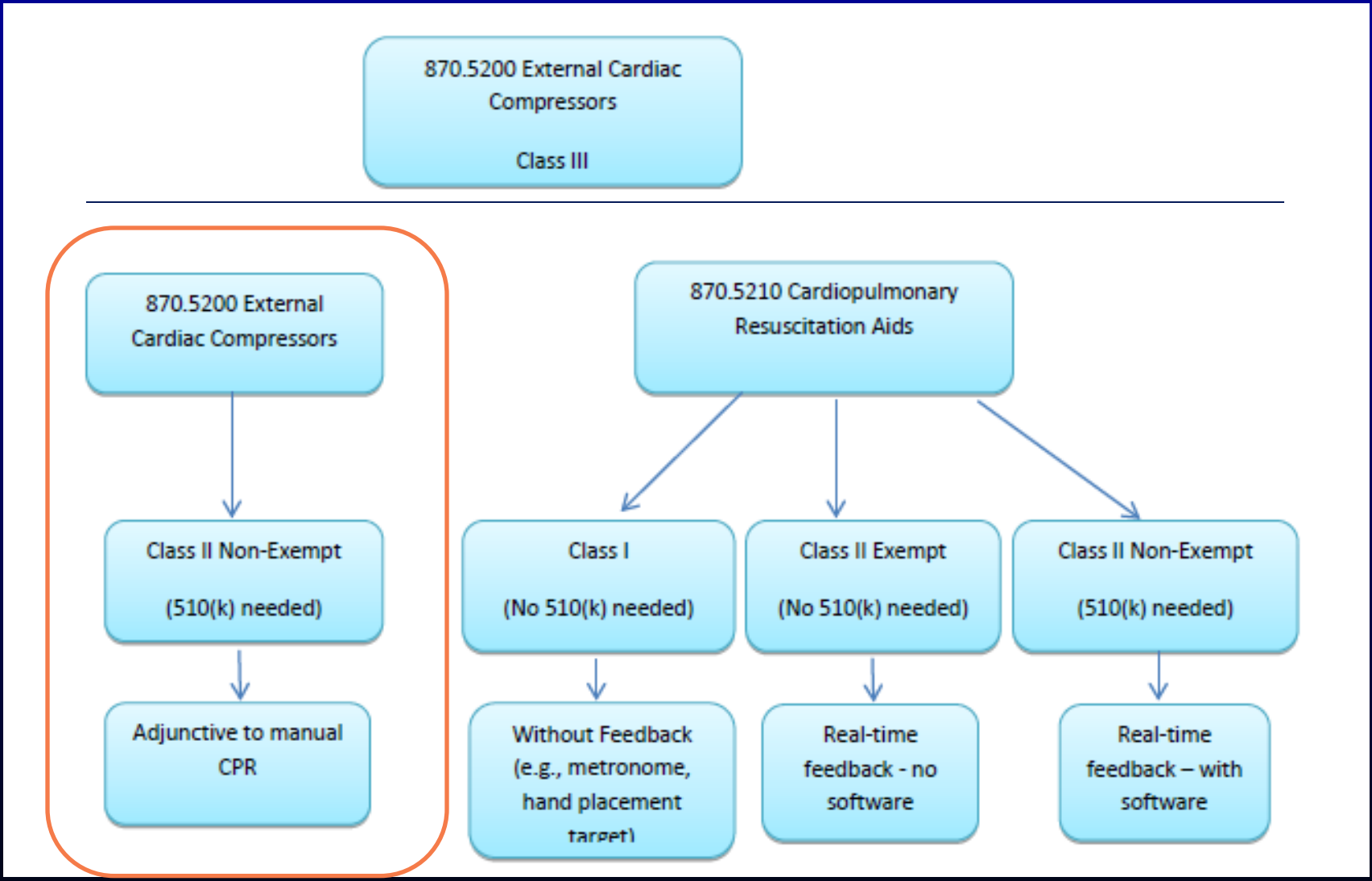

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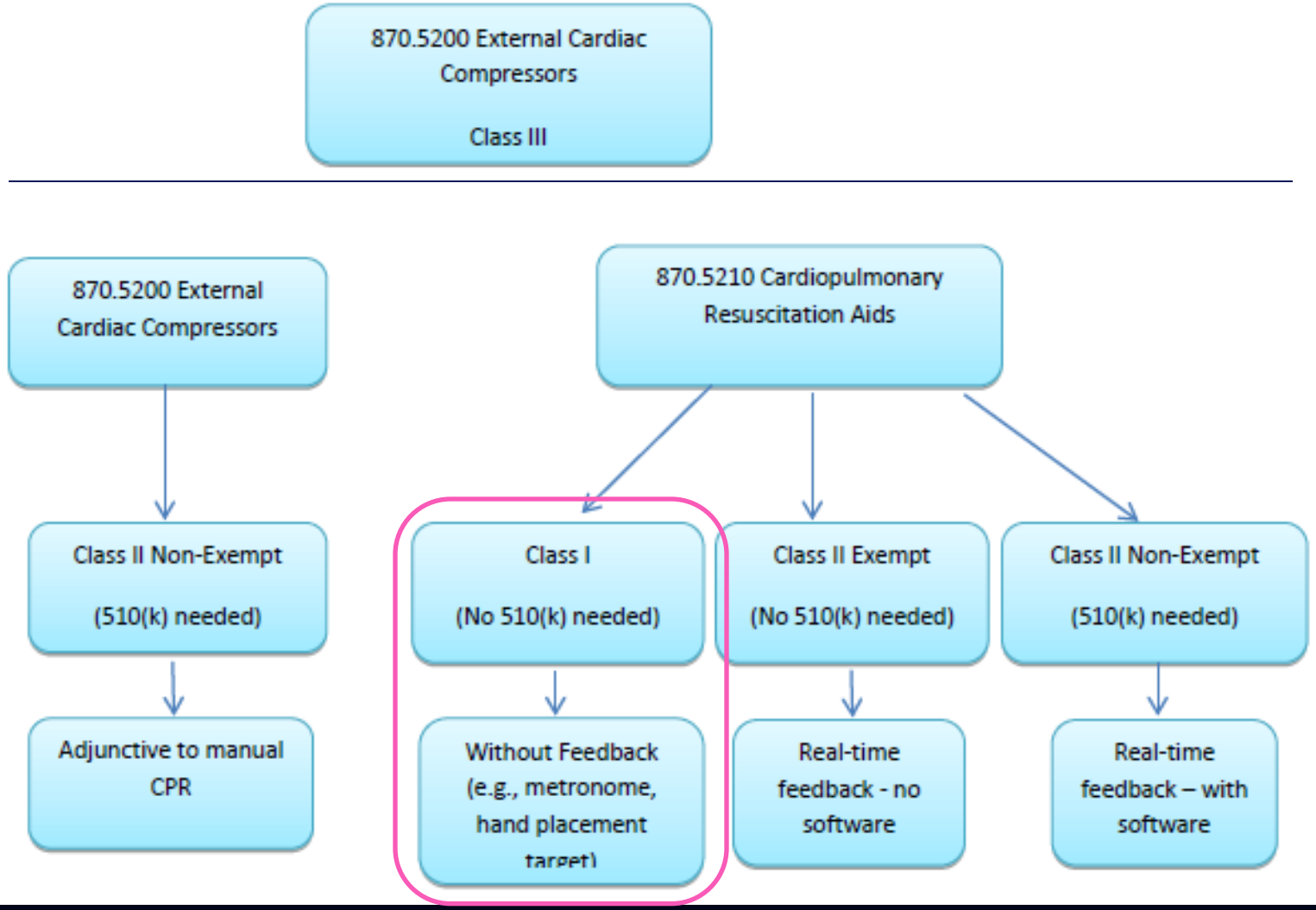
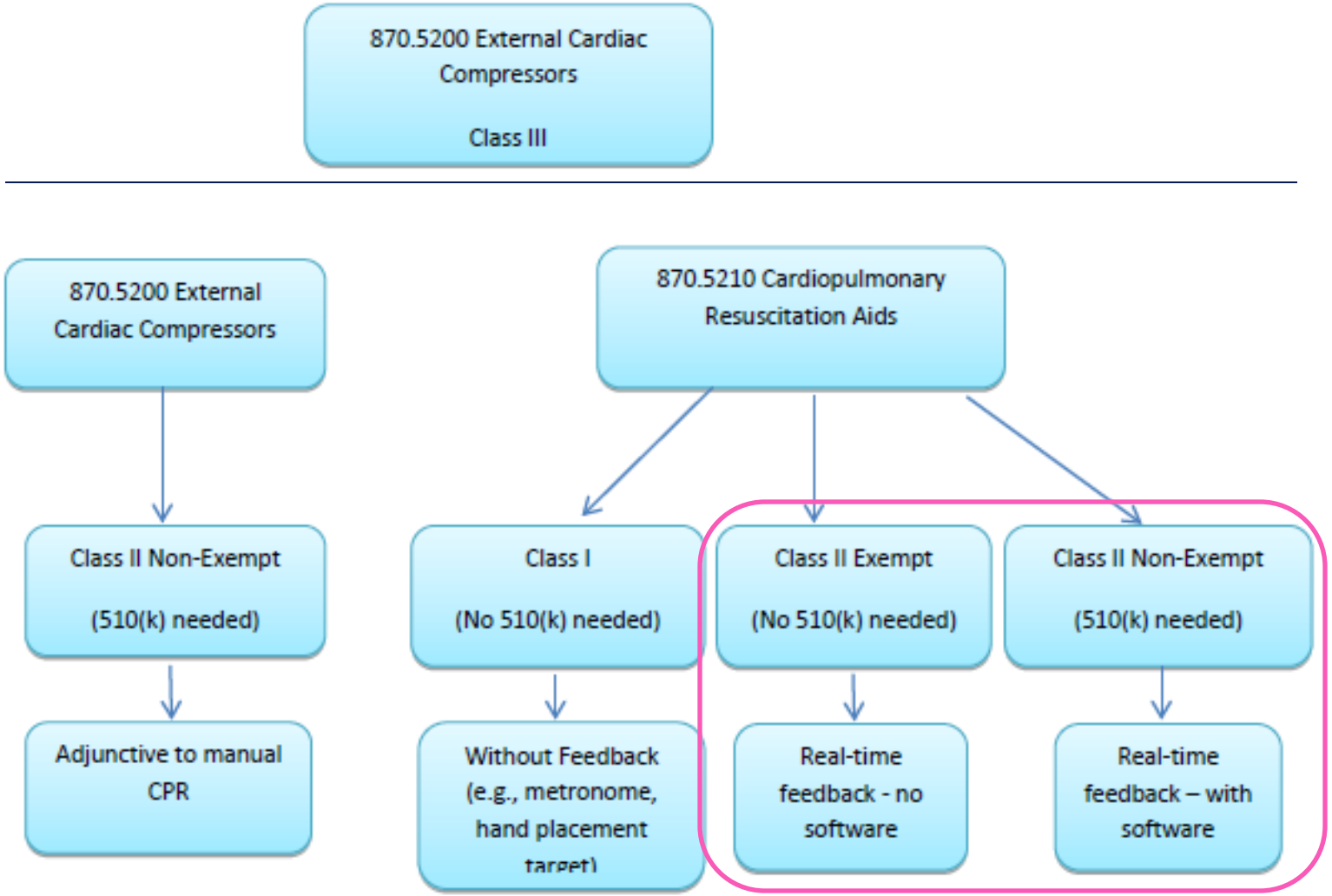


FDA Proposal



Risks to Health
ECC Devices

- Cardiac arrhythmias and electrical shock
- Tissue/Organ damage
- Bone breakage
- Inadequate blood flow

Adverse tissue reaction - removed due to benefit/risk profile

Risks to Health
CPR Aid Devices

- Suboptimal CPR Delivery

Adverse tissue reaction - removed due to benefit/risk profile

Clinical Evidence

- MDR Reports
- Literature Review
- Clinical Perspective

MDR Report

External Cardiac Compressors 870.5200 (DRM)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Sum
Death							2	1			4	7	14
Injury						1		2	4	4	3	6	20
Malfunction			1	11	10	1	5	6	5	3	8	38	88
Invalid Data											1	2	3
Other						3	1	3				2	9
Sum			1	11	10	5	8	12	9	7	16	55	134

MDR Report

CPR Aid Devices (LIX)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Sum
Death													
Injury									1				1
Malfunction												3	3
Invalid Data													
Other													
Sum									1			3	4

Literature Review

Xianghua (Henry) Yin, MD

Systematic Literature Review
External Cardiac Compressors

Xianghua Yin, MD
Epidemiologist
Division of Epidemiology
Office of Surveillance and Biometrics
Center for Devices and Radiological Health

Outline

- Objective
- Methods
- Findings on safety and efficacy/effectiveness
- Discussion of strengths and limitations
- Summary

Objective

To provide safety and efficacy/effectiveness information on the use of the following devices in at assisting in CPR delivery.

- External Cardiac Compressors (ECC)
- Cardiopulmonary Resuscitation (CPR) Aid devices

Methods

- PubMed search limited to English (May 22, 2013)
- External Cardiac Compressors
  - “external cardiac compressor”, "automated chest compression“, "active chest compression“, “mechanical chest compression", "chest compression mechanical devices“, "automated CPR“, "load distributing band chest compression device“, “piston-driven”, "cardiopulmonary resuscitation“, "Out-of-hospital Cardiac Arrest", "in-hospital Cardiac Arrest"
- CPR Aid devices
  - "audio feedback", "audible feedback“, "visual feedback“, “audiovisual feedback”, "real-time feedback“, "real-time audiovisual feedback“, "Out-of-hospital Cardiac Arrest", "in-hospital Cardiac Arrest"

Exclusion Criteria

- Case reports, case series (n<10), non-clinical research (e.g. non-clinical method papers, editorial, etc.)
- No human data, only animal data, only data on active compression/decompression compressors, only data on other devices used in CPR
- No safety or efficacy/effectiveness endpoints related to the use of ECCs and/or CPR Aid devices
- Outside of US data

EXTERNAL CARDIAC COMPRESSORS (ECC)

Article Retrieval and Selection
ECC

Records identified using PubMed through 5/22/2013 (n=440)

Records excluded (n=430)

- Non-English (n=32)
- Non-human studies (n=162)
- No safety/effectiveness endpoints (n=23)
- Non-clinical research (n=72)
- Irrelevant to ECC devices (n=110)
- Data on active compression/decompression compressors (n=14)
- OUS data (n=17)

Articles included in qualitative review (n=10)

Systematic Literature Review Characteristics of the ECC Studies

Study Design	Number of Articles
Meta-analysis/Systematic review	3
Randomized clinical trial (RCT)	4
Post-hoc analysis	1
Cohort study	1
Case-control study	1

Publication years: 1978 – 2013

Safety of ECC Devices

- Only 1 out of 10 studies reported adverse events
- RCT with 50 patients (Manual 26, Mechanical 24)[1]
  - Thumper vs. Manual-CPR
- Rib or sternal fractures
  - Mechanical: 77% vs. Manual: 47%
  - RR 1.63 (95% C.I. 0.91-2.94)
- Internal organ injury:
  - Mechanical: 0% vs. Manual: 12%
  - RR 0.26 (95% C.I. 0.01-4.94)

1: Taylor et al. 1978

Efficacy of ECC

Author, Year	Sample size	Return of Spontaneous Circulation (ROSC)	Survival to hospital discharge	Survival to 4 hours	Neurological status at hospital discharge
Taylor, 1978	50 (1:1)	-	Mechanical 12% Manual 8%	-	-
Ward, 1993	15	-	No survivors	-	-
Dickinson, 1998	20 (1:1)	-	No survivors	-	-
Hallstrom - ASPIRE*, 2006	1,071(1:1)	-	Mechanical 5.8% Manual 9.9%	Mechanical 29.5% Manual 28.5%	CPC** score of 1 or 2 Mechanical 3.1% Manual 7.5% (p<0.01)
Brooks, 2011†	868	N=51, RR 2.81 [95% CI, 0.96,8.22]	-	-	-
Ong, 2012§	2,611	-	-	-	-
Westfall, 2013	6,538	OR 1.53 [95% CI, 1.32,1.78]	-	-	-

*AutoPulse Assisted Prehospital International Resuscitation (ASPIRE) Trial; **Cerebral Performance Category (CPC): score 1 (Conscious and alert) , 2 (Conscious);

†Halperin, et al (1993) study was excluded as the device was not under DRM product code.

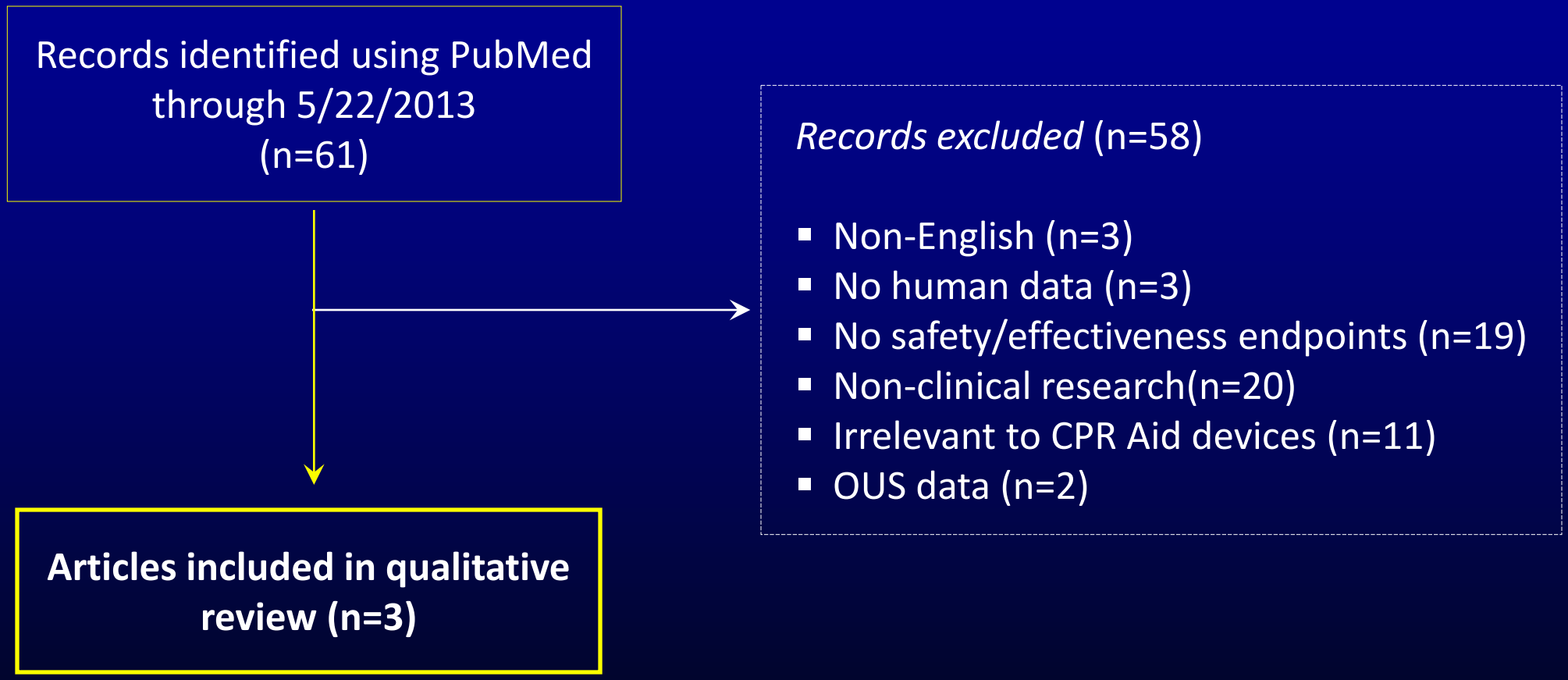
§7 supported the superiority of the use of mechanical CPR,1 was neutral, and 2 supported the superiority of use of manual CPR.

Effectiveness of ECC Observational studies Load Distributing Band (LBD)-CPR vs. Manual-CPR

- Cohort study (Ong et al, 2006): N=783
  - ROSC: 34.5% vs. 20.2%, P < 0.05
  - Survival to hospital admission: 20.9% vs. 11.1%, P< 0.05
  - Survival to hospital discharge: 9.7% vs. 2.9%, p< 0.05
  - Cerebral Performance Category score 1:15% vs. 6%, P=0.36
  - Overall Performance Category score 1: 4.7% vs. 2.3%, p=0.40
- Case-control study (Casner et al, 2005): N=262
  - ROSC: 39% vs. 29%, P < 0.05

CPR AID DEVICES

Article Retrieval and Selection
CPR Aid Devices



Characteristics of the CPR Aid Studies

Study Design	Number of Articles
Randomized clinical trial	1
Cohort study	2

Publication years: 2005-2011

CPR Aid Devices Results

- Safety: None of three included studies reported adverse events.
- Efficacy: 1 RCT (Hostler et al, 2011): N=1586
  - Real-time audio and visual feedback Device: Q-CPR, Philips Medical Systems
  - Feedback-off (n=771) vs. feedback-on (n=815)
  - OHCA setting
  - No statistically significant results for ROSC (45% vs. 44%), survival to hospital discharge (12% vs. 11%), and awake at hospital discharge (10% vs. 10%)

CPR Aid Devices Results

- Effectiveness: 2 Observational studies
  - N=67-156 pts
  - Audiovisual feedback device
    - Heartstart 4000SP, Philips Medical Systems
  - In-hospital cardiac arrest setting
  - No statistically significant results for ROSC and survival to hospital discharge
  - Consistent CPR performance measures as use of feedback device helps consistent CPR delivery

Strengths and Limitations

- Strengths: Except for English publications, no other limits applied
- Limitations:
  - Limited number of studies published
  - Small sample sizes (n≤ 50)
  - Failed to include survival & neurologic status at discharge as endpoints
  - Inadequate reporting of adverse events
  - Mechanical CPR should be compared w/ high quality manual CPR
  - Only one style of feedback (i.e. audio feedback) evaluated

Summary

- For the ECC devices, there is a lack of consistent data available to suggest that external cardiac compressors can be used in place of effective standard manual CPR.

- For the CPR Aid devices, the available data suggest that CPR can be applied more consistently compared to no device; however, this effect did not translate into any net difference in positive clinical outcomes.

Concluding Remarks

Catherine P. Wentz, M.S.

American Heart Association's 2010 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

- High quality CPR saves lives

  "Minimize interruptions in effective chest compressions until ROSC or termination of resuscitative efforts"

  "It is important to reduce time to first chest compressions"

- "Non-standard" CPR can also save lives

  "Encourage Hands-Only (compression only) CPR for the untrained lay rescuer…"

  "High-frequency chest compressions may be considered by adequately trained rescue personnel as an alternative"

Circulation. 2010;122:S640-S656

Clinical Rationale for Down-regulation AHA Guidelines for CPR

"the actions of bystanders and other care providers must occur within a system that coordinates and integrates each facet of care into a comprehensive whole, focusing on survival to discharge from the hospital."

- "CPR prompt and feedback devices can be useful as part of an overall strategy to improve the quality of CPR during actual resuscitations"

- "Mechanical piston devices may be considered for use by properly trained personnel in specific settings for the treatment of adult cardiac arrest in circumstances (e.g., during diagnostic and interventional procedures) that make manual resuscitation difficult"

Safety and Effectiveness

- External Cardiac Compressors
- CPR Aid Devices

Risks to Health
ECC Devices

- Cardiac arrhythmias and electrical shock
- Tissue/Organ damage
- Bone breakage
- Inadequate blood flow

Special Controls
ECC Devices

- Cardiac arrhythmias and Electrical Shock
  - *Electrical Safety, EMC, labeling*
- Tissue/Organ Damage
  - *Bench studies, labeling, training*
- Bone breakage
  - *Bench studies, labeling, training*
- Inadequate blood flow
  - *Bench studies, labeling, training*

Risks to Health
CPR Aid Devices

- Suboptimal CPR Delivery

CPR Aid Devices without Feedback General Controls Sufficient

General controls to mitigate suboptimal CPR delivery

Labeling

Intended for use by professionally trained rescuers

Quality system regulation requirements

including design controls for devices that include software

CPR Aid Devices with Feedback Proposed Special Controls

Proposed Special Controls to mitigate suboptimal CPR delivery

- Bench Studies
- Human Factors testing
- Labeling

Recommendation

870.5200 External Cardiac Compressor

(a)Identification. An external cardiac compressor is an external device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest. External cardiac compressor devices are used as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, extended CPR when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR.

(b)Classification: Class II (Special Controls)

Recommendation

870.5210 Cardiopulmonary Resuscitation Aid Device

CPR Aid Device without feedback

(1) Identification: A CPR Aid without feedback is a device that performs a simple function such as proper hand placement and/or simple prompting for rate and/or timing of compressions/breathing for the professionally trained rescuer, but offers no real-time feedback related to the quality of the CPR being provided. These devices should be utilized by persons professionally trained in cardiopulmonary resuscitation, to assure proper use and the delivery of optimal CPR to the victim.

(a)Classification: Class I (general controls)

Recommendation

870.5210 Cardiopulmonary Resuscitation Aid Device

CPR Aid Device with feedback

(1) *Identification:* A CPR Aid device with feedback is a device that provides real-time feedback to the rescuer regarding the quality of CPR being delivered to the victim, and provides either audio and/or visual information to encourage the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines (e.g., to include, but not be limited to, parameters such as compression rate, compression depth, ventilation, recoil, instruction for one or multiple rescuers, etc.). These devices may also perform a coaching function to aid rescuers in the sequence of steps necessary to perform effective CPR on a victim.

(2) *Classification:* Class II (special controls). The device is exempt from the premarket notification procedures in subpart E of part 807 of this chapter if it does not contain software (e.g., is mechanical or electro-mechanical).

Thank You!

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Questions

External Cardiac Compressors and Cardiopulmonary Resuscitation Aid Devices

September 11, 2013, Meeting of the Circulatory System Devices Panel

Question 1

FDA has identified the following risks to health for external cardiac compressors (ECC) intended as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR, based on the input of the prior classification panels, review of industry responses to the 2009 515(i) order, review of responses to the January 8, 2013 proposed order, the Manufacturer and User facility Device Experience (MAUDE) database, and FDA's literature review:

- Cardiac arrhythmias or Electrical Shock
- Tissue/Organ Damage
- Bone breakage (ribs, sternum)
- Inadequate blood flow

Question 1 continued…

Is this a complete and accurate list of the risks to health presented by external cardiac compressors intended as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR? Please comment on whether you disagree with inclusion of any of these risks or whether you believe any other risk should be included in the overall risk assessment of external cardiac compressors.

Question 2

FDA has identified the following risks to health for CPR Aid devices without Feedback intended to aid the professionally trained rescuer in the consistent and efficient application of CPR throughout the duration of therapy, based on the input of the prior classification panels, review of industry responses to the 2009 515(i) order, review of responses to the January 8, 2013 proposed order, the MAUDE database, and FDA's literature review:

- Suboptimal CPR Delivery

Question 2 continued…

Is this a complete and accurate list of the risks to health presented by CPR Aid devices without Feedback intended to aid the professionally trained rescuer in the consistent and efficient application of CPR throughout the duration of therapy? Please comment on whether you disagree with inclusion of any of these risks or whether you believe any other risk should be included in the overall risk assessment of CPR aid devices without feedback.

Question 3

FDA has identified the following risks to health for CPR Aid devices with Feedback intended to provide real-time audio and/or visual training and/or feedback to the rescuer regarding the application of and quality of CPR being delivered to the victim, as well as providing encouragement to the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines, based on the input of the prior classification panels, review of industry responses to the 2009 515(i) order, review of responses to the January 8, 2013 proposed order, the MAUDE database, and FDA's literature review:

- Suboptimal CPR Delivery

Question 3 continued….

Is this a complete and accurate list of the risks to health presented by CPR Aid devices with Feedback intended to provide read-time audio and/or visual training and/or feedback to the rescuer regarding the application of and quality of CPR being delivered to the victim, as well as providing encouragement to the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR? Please comment on whether you disagree with inclusion of any of these risks or whether you believe any other risk should be included in the overall risk assessment of CPR aid devices with feedback.

Question 4

As defined in 21 CFR 860.7(d)(1), there is reasonable assurance that a device is safe when it can be determined, based upon valid scientific evidence, that the probable benefits to health from use of the device for its intended uses and conditions of use, when accompanied by adequate directions and warnings against unsafe use, outweigh any probable risks. As defined in 21 CFR 860.7(e)(1), there is a reasonable assurance that a device is effective when it can be determined, based on valid scientific evidence, that in a significant portion of the target population, the use of the device for its intended uses and conditions of use, when accompanied by adequate directions for use and warnings against unsafe use, will provide clinically significant results.

Question 4 continued….

a. The FDA believes that available scientific evidence supports an adequate assurance of safety and effectiveness for ECC intended as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR.

   (1) Do you agree that the available scientific evidence is adequate to support the safety and effectiveness for external cardiac compressors when used as intended?

   (2) Do the probable benefits to health from use of the external cardiac compressor outweigh the probable risks to health when used as intended?

Question 4 continued….

b. The FDA believes that available scientific evidence supports an adequate assurance of safety and effectiveness for CPR Aid Devices without Feedback intended to aid the professionally trained rescuer in the consistent and efficient application of CPR throughout the duration of therapy.

   (1) Do you agree that the available scientific evidence is adequate to support the safety and effectiveness for CPR Aid Devices without Feedback when used as intended?

   (2) Do the probable benefits to health from use of the CPR Aid Devices without Feedback outweigh the probable risks to health when used as intended?

Question 4 continued….

c. The FDA believes that available scientific evidence supports an adequate assurance of safety and effectiveness for CPR Aid Devices with Feedback intended to provide real-time audio and/or visual training and/or feedback to the rescuer regarding the application of and quality of CPR being delivered to the victim, as well as providing encouragement to the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines.

(1) Do you agree that the available scientific evidence is adequate to support the safety and effectiveness for CPR Aid Devices with Feedback when used as intended?

(2) Do the probable benefits to health from use of the CPR Aid Devices with Feedback outweigh the probable risks to health when used as intended?

Question 5

FDA believes that the following special controls can adequately mitigate the risks to health for ECC devices intended as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR:

- Performance testing under simulated physiological conditions must demonstrate the reliability of the delivery of specific compression depth and rate over the intended duration and environment of use;
- Labeling must include the clinical training for the safe use of this device and information on the patient population for which the device has been demonstrated to be effective;

Question 5 continued….

- For devices that incorporate electrical components, appropriate analysis and testing must validate electrical safety and electromagnetic compatibility; and
- For devices containing software, software verification, validation, and hazard analysis must be performed.

a. Please comment on whether these special controls are adequate to mitigate the risks to health for external cardiac compressors when used as intended and provide sufficient evidence of safety and effectiveness.

b. Please comment on whether you disagree with inclusion of any of these special controls, or whether you believe any other special controls are necessary.

Question 6

FDA believes that general controls and software design controls (where applicable) can adequately mitigate the risks to health for CPR Aid Devices without Feedback intended to aid the professionally trained rescuer in the consistent and efficient application of CPR throughout the duration of therapy. Do you agree that general controls are adequate to mitigate the risks to health for CPR Aid Devices without Feedback when used as intended and provide sufficient evidence of safety and effectiveness?

Question 7

FDA believes that the following special controls can adequately mitigate the risks to health for CPR Aid Devices with Feedback intended to provide real-time audio and/or visual training and/or feedback to the rescuer regarding the application of and quality of CPR being delivered to the victim, as well as providing encouragement to the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines:

- Performance testing under simulated physiological or use conditions must demonstrate the accuracy and reliability of the feedback to the user on specific compression rate, ventilation rate, and/or depth over the intended duration of use;

Question 7 Continued

- Labeling must include the clinical training, if needed, for the safe use of this device and information on the patient population for which the device has been demonstrated to be effective;
- For devices that incorporate electrical components, appropriate analysis and testing must validate electrical safety and electromagnetic compatibility;
- For devices containing software, software verification, validation, and hazard analysis must be performed;
- Human factors testing and analysis must validate that the device design and labeling are sufficient for the intended user.

Question 7 Continued

a. Please comment on whether these special controls are adequate to mitigate the risks to health for external cardiac compressors when used as intended and provide sufficient evidence of safety and effectiveness?

b. Please comment on whether you disagree with inclusion of any of these special controls, or whether you believe any other special controls are necessary.

Question 8

21 CFR 860.93 describes the classification of implants, life-supporting or life-sustaining devices and states that “the classification panel will recommend classification into class III of any implant or life-supporting or life-sustaining device unless the panel determines that such classification is not necessary to provide reasonable assurance of the safety and effectiveness of the device. If the panel recommends classification or reclassification of such a device into a class other than class III, it shall set forth in its recommendation the reasons for so doing…” FDA continues to believe that external cardiac compressors may be considered life-supporting, which was supported by the original classification panel. However, FDA believes that the risks to health for ECC devices can be mitigated with special controls, in conjunction with general controls, and therefore recommends that these devices be reclassified as class II devices.

Question 8 Continued

a. Please comment on whether you believe that external cardiac compressors are life-supporting medical devices.

b. Based on the available scientific evidence and proposed special controls, what classification do you recommend for external cardiac compressors?

c. In accordance with 860.93, if you recommend a classification other than class III for any of these indications, please discuss the reasons for your recommendation.

Question 9

21 CFR 860.93 describes the classification of implants, life-supporting or life-sustaining devices and states that “the classification panel will recommend classification into class III of any implant or life-supporting or life-sustaining device unless the panel determines that such classification is not necessary to provide reasonable assurance of the safety and effectiveness of the device. If the panel recommends classification or reclassification of such a device into a class other than class III, it shall set forth in its recommendation the reasons for so doing…”

Question 9 Continued

a. Please comment on whether you believe that CPR Aid devices are life-supporting medical devices.

b. Based on the available scientific evidence, what classification do you recommend for CPR Aid devices without Feedback?

c. Based on the available scientific evidence and proposed special controls, what classification do you recommend for CPR Aid devices with Feedback?

d. In accordance with 860.93, if you recommend a classification other than class III for any of these indications, please discuss the reasons for your recommendation.